Project CHECKVIS: Real-time and retrospective monitoring of appointment check-ins to detect abnormal behaviour

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Abstract

Purpose: Online room management systems (ORMS) that integrate self-service check-in kiosks have proven to be beneficial for both patients and healthcare providers when implemented in the healthcare industry. At the Cedars Cancer Centre, the ORMS is used along side user-friendly kiosks to check-in patients for their appointments. Occasionally, patients are unable to check-in due to system failures that lead to kiosk downtime. A real-time logging tool that visualizes both retrospective and current kiosk activity can be used to detect downtime periods in the ORMS.

Methods: The real-time logging tool was generated using JavaScript and HTML. The log file data was organized to ultimately visualize kiosk activity in HighCharts.

Results: The activity of individual or multiple kiosks can be visualized using the real-time logging tool. Analysis of these plots for May 24, 2017, demonstrates irregular heartbeat activity which indicates kiosk downtime. Successful and unsuccessful check-in activity can also be visualized.

Conclusion: Kiosk downtime can be detected using a real-time logging tool that visualizes kiosk activity against time. This information has the potential

to improve the ORMS and to uncover normalities and abnormalities within the system for future research.

Introduction

Self-service technological advances have revolutionized service delivery resulting in increased consumer satisfaction, reduced costs and improved efficiency (Lu et al., 2009). This technology has attracted a number of industries, most notably the airline, hospitality, food retail and banking industries (Liljander et al., 2006). Consequently, consumers have become accustomed to self-service technologies that integrate the Internet, mobile phones and/or kiosks to their online management systems. It is therefore not surprising that the use these systems has extended to the healthcare industry. As a result, extensive research and development has been carried out regarding the use of similar systems within hospital environments (Caprani et al., 2012). Hospitals aim to provide a similar experience to their patients by optimizing administrative tasks and developing tools that manage personal healthcare.

The implementation of check-in kiosks is an attractive option for optimizing hospital registration (Rhoads and Drazen, 2009a). Evidence has shown that the use of check-in kiosks in hospitals is more convenient, leading to reduced wait times and improved patient satisfaction (Rhoads and Drazen, 2009a). The operational benefits for hospitals include reduced costs, increased patient throughput and improved data quality (Rhoads and Drazen, 2009a). It is important to note that this technology is used as a means to supplement, not replace staff (Rhoads and Drazen, 2009a). These technologies allow staff to allocate their time more efficiently (Caprani et al., 2012). This is crucial in a hospital environment, where staff cannot always provide patients with the amount of time they require (Caprani et al., 2012). As a result, less time is spent on administrative work and more time is spent providing care for patients (Caprani et al., 2012).

The integration of self check-in kiosks in online room management systems within hospitals is not a novel idea. Since the late 1990s, patients in Andalucia, Spain have completed hospital registration using their health cards through the the Infosalud system (Jones, 2009). More recently, hospitals in the United Kingdom have installed e-reception systems to optimize the appointment registration process (Jones, 2009). In this system, patients check in using touchscreen kiosks and an eWhiteboard allows hospital staff to monitor patients in the waiting room electronically (Jones, 2009). As a result of these success stories, similar registration approaches that integrate self-service kiosks into patient administration systems have been subsequently developed throughout the world (Jones, 2009).

In Canada, a number of companies including Chronometriq, Qwick Media and IBM have developed efficient online room management systems for the healthcare industry (hos; inc; kio). The Chronometriq system for example, is used by patients in Quebec and Ontario, allowing patients to notify administrative staff of their appointment arrival via self-service kiosks. Ultimately, these companies have developed systems with a similar goal in mind. They aim to improve healthcare services by optimizing the interactions between patients and healthcare providers (hos).

At the Cedars Cancer Centre, the Online Room Management System (ORMS) is used to check-in patients for their appointments. The system consists of a user-friendly kiosk check-in system, a virtual waiting room providing staff with important information regarding patient queues, and a digital screen call-in system. To check-in, patients scan their RAMQ medicare cards at barcode-reader kiosks. In total, there are 6 kiosks at the Cedars Cancer Centre. Each kiosk can be distinguished by their kiosk ID. It is important to note that 2 kiosks on the ground floor have the same ID. Both kiosks are identified as DS1_1. Kiosks DS1_1, DS1_1 and DS1_2 are located on the ground floor while kiosks DRC_1, DRC_2 and DRC_3 are located on the first floor. Exact kiosk locations are indicated in Fig.11. and Fig.12. in the Appendix (11). Ultimately, the ORMS provides valuable time-stamp data regarding each patient's trajectory, from the moment they check-in, throughout the waiting period, until they are called to their appointment. In the future, Cedars Cancer Centre patients will also be able to check-in using the Oncology portal and application (Opal) mobile phone app. One of Opal's key features, is its ability to estimate radiation oncology patient wait times in real-time. The estimates are determined through machine-learning algorithms based on the time-stamp data of previous patients.

Occasionally, database errors or other system failures may lead to downtime of the system. During these periods, patients are unable to check-in via hospital kiosks and are therefore sent to the hospital reception. As a result, the system is unable to monitor the patient's trajectory and assess wait times. During these periods, the ORMS is unable to meet patients needs, therefore patient satisfaction is at risk (Kamali et al., 2013).

Objective

The aim of this project is to develop a real-time logging tool that uses log file data to visualize kiosk activity at the Cedars Cancer Centre. The retrospective log file data will be used to determine normality within the system. In the future, real-time monitoring will detect abnormality within the system.

Materials and Methods

Log File

Log File Structure

Data regarding the activity and downtime of all kiosks at the Cedars Cancer Centre are stored within DAT log files. The log files are updated in real-time, corresponding to a new log file each day. A sample log file for kiosk activity on May 24, 2017 is displayed in Fig. 1. It is important to note that empty lines were removed from the original file and that patient names were anonymized prior to analysis.

Key information regarding kiosk activity can be extracted from the log file. Each line is organized in a chronological manner, containing the date, time, kiosk ID and kiosk message. The message corresponds to the action carried out by the aforementioned kiosk at a specific time-stamp.

```
['5/24/2017 8:16:49,', '8:16:49,', 'RAMQ,', 'DRC_3,', '<center>Please', 'scan', 'your', 'medicare', 'card', 'to', 'ch
eck', 'in.<br>', '</center>,', ',', 'hereDefault,', '<center>Please', 'scan', 'your', 'medicare', 'card', 'to', 'chec
k', 'in.<br>', '</center>']
['5/24/2017 8:17:35,', '8:17:35,', 'RAMQ,', 'DS1_1,', '<center>Please', 'scan', 'your', 'medicare', 'card', 'to', 'ch
eck', 'in.<br>', '</center>,', ',', 'hereDefault,', '<center>Please', 'scan', 'your', 'medicare', 'card', 'to', 'chec
k', 'in.<br>', '</center>']
['5/24/2017 8:17:52,', '8:17:52,', 'RAMQ,', 'DRC_1,', '<center>Please', 'scan', 'your', 'medicare', 'card', 'to', 'ch
eck', 'in.<br>', '</center>,', ',', 'hereDefault,', '<center>Please', 'scan', 'your', 'medicare', 'card', 'to', 'chec
k', 'in.<br>', '</center>']
['5/24/2017 8:17:53,', '8:17:53,', 'RAMQ,', 'DRC_2,', 'Retrieving', 'information', 'for', '<span', 'style="background
-color:', '#ffff00">PatientName</span>']
['5/24/2017 8:17:56,', '8:17:56,', 'RAMQ,', 'DRC_2,', 'Please', 'have', 'a', 'seat', 'in', 'the', 'waiting', 'room.',
'Your', 'name', 'will', 'appear', 'on', 'the', 'screen', 'when', 'you', 'are', 'called.<br>', ',', 'DRC,', 'hereRC,',
'Please', 'have', 'a', 'seat', 'in', 'the', 'waiting', 'room.', 'Your', 'name', 'will', 'appear', 'on', 'the', 'scree
n', 'when', 'you', 'are', 'called.<br>']
['5/24/2017 8:18:16,', '8:18:16,', 'RAMQ,', 'DRC_2,', '<center>Please', 'scan', 'your', 'medicare', 'card', 'to', 'ch
eck', 'in.<br>', '</center>,', ',', 'hereDefault,', '<center>Please', 'scan', 'your', 'medicare', 'card', 'to', 'chec
k', 'in.<br>', '</center>']
['5/24/2017 8:18:36,', '8:18:36,', 'RAMQ,', 'DS1_1,', '<center>Please', 'scan', 'your', 'medicare', 'card', 'to', 'ch
eck', 'in.<br>', '</center>,', ',', 'hereDefault,', '<center>Please', 'scan', 'your', 'medicare', 'card', 'to', 'chec
k', 'in.<br>', '</center>']
['5/24/2017 8:19:0,', '8:19:0,', 'RAMQ,', 'DS1_2,', '<center>Please', 'scan', 'your', 'medicare', 'card', 'to', 'chec
k', 'in.<br>', '</center>,', ',', 'hereDefault,', '<center>Please', 'scan', 'your', 'medicare', 'card', 'to', 'chec
k', 'in.<br>', '</center>']
['5/24/2017 8:20:9,', '8:20:9,', 'RAMQ,', 'DRC_3,', '<center>Please', 'scan', 'your', 'medicare', 'card', 'to', 'chec
k', 'in.<br>', '</center>,', ',', 'hereDefault,', '<center>Please', 'scan', 'your', 'medicare', 'card', 'to', 'chec
k', 'in.<br>', '</center>']
```

Figure 1: Sample Log File

In general, there are 9 possible messages that may be displayed on the kiosk screen, which depend on prior action. The possible messages are listed below.

1. Please scan your medicare card to check in.
2. Please have a seat in the waiting room.
3. If you did not already have your blood test, please check in at the Test Centre Reception.
4. Please have a seat in the waiting room. Your name will appear on the screen when you are called.
5. Retrieving information for <patient name>.
6. If you did not already have your blood test, please check in at the Test Centre Reception. Otherwise, please have a seat in the waiting room. Your name will appear on the screen when you are called.

7. Please go to the reception to have your photo taken.
8. Please check in at the reception.
9. Unable to check you in at this time.

Approximately every 3 minutes, the kiosk sends a message to the system, which ensures that the kiosk is active. The aforementioned message represents the “heartbeat” of a kiosk and is listed above as message 1. When a patient successfully checks-in, a message is displayed on the kiosk screen which confirms the check-in then directs the patient to the appropriate location. Successful check-in messages include the messages between 2-7 listed above. Otherwise, a patient is unable to check-in and an unsuccessful check-in message is shown. Unsuccessful check-in messages occur when either message 8 or 9 is displayed on the kiosk screen.

Organizing Log File Data

y-value	Kiosk Activity	Kiosk Message on Log File
1	Heartbeat	1. Please scan your medicare card to check in.
2	Successful Check-In	2. If you did not already have your blood test, please check in at the Test Centre Reception.
		3. Please have a seat in the waiting room. Your name will appear on the screen when you are called.
		4. Retrieving information for ¡patient name¿.
		5. If you did not already have your blood test, please check in at the Test Centre Reception. Otherwise, please have a seat in the waiting room. Your name will appear on the screen when you are called.
		6. Please go to the reception to have your photo taken.
3	Unsucessful Check-In	7. Please check in at the reception.
		8. Unable to check you in at this time.

Table 1: Summarized Log File Organization

To enable the visualization of kiosk activity, a plot of kiosk activity versus time was created. Using log file data, the time-stamp of each line was extracted to represent the x-value while kiosk activity was represented by 3 designated y-values. Lines within the log file containing “heartbeat” messages were set equal to a y-value of 1. Lines that included successful check-in messages were assigned a y-value of 2. Lines that represented unsuccessful check-ins as indicated by the kiosk message were assigned a y-value of 3. The following information is summarized in Table 1.

To organize the log file data, a dictionary was created that stored kiosk activity values. Each key in the dictionary represented a kiosk ID. Each kiosk ID was attributed to a list which held pairs of x- and y-coordinates. Ultimately, each key in the dictionary represented a variable in the plot that contained a distinct set of coordinates which gave rise to an interpretation of kiosk activity throughout a time period. A sample of the dictionary created for the May 24, 2017 log file is shown in Fig.2. In this example, the kiosk activity for kiosk DRC_2 is displayed. It is important to note that the x-values in Fig.2. were subsequently converted to UNIX time to enable accurate visualization of data upon plotting.


```
{'DRC_2': [['0:0:28', 1], ['0:3:49', 1], ['0:7:9', 1], ['0:10:30', 1], ['0:13:51', 1], ['0:17:11', 1], ['0:20:31',
1], ['0:23:52', 1], ['0:27:12', 1], ['0:30:32', 1], ['0:33:52', 1], ['0:37:13', 1], ['0:40:33', 1], ['0:43:53', 1],
['0:47:13', 1], ['0:50:33', 1], ['0:53:54', 1], ['0:57:14', 1], ['1:0:34', 1], ['1:3:54', 1], ['1:7:15', 1], ['1:10:3
5', 1], ['1:13:55', 1], ['1:17:15', 1], ['1:20:35', 1], ['1:23:56', 1], ['1:27:16', 1], ['1:30:36', 1], ['1:33:56',
1], ['1:37:17', 1], ['1:40:37', 1], ['1:43:57', 1], ['1:47:17', 1], ['1:50:37', 1], ['1:53:58', 1], ['1:57:18', 1],
['2:0:38', 1], ['2:3:58', 1], ['2:7:19', 1], ['2:10:39', 1], ['2:14:0', 1], ['2:17:20', 1], ['2:20:40', 1], ['2:24:
1', 1], ['2:27:21', 1], ['2:30:41', 1], ['2:34:1', 1], ['2:37:21', 1], ['2:40:42', 1], ['2:44:2', 1], ['2:47:22', 1],
['2:50:42', 1], ['2:54:3', 1], ['2:57:23', 1], ['3:0:43', 1], ['3:4:4', 1], ['3:7:24', 1], ['3:10:44', 1], ['3:14:8',
1], ['3:17:29', 1], ['3:20:49', 1], ['3:24:9', 1], ['3:27:30', 1], ['3:30:50', 1], ['3:34:10', 1], ['3:37:30', 1],
```


Figure 2: Sample of Dictionary

Plotting Data using HighCharts

The plots generated in this project were visualized using HighCharts. HighCharts is an open source JavaScript charting library that allows users to create interactive charts for the visualization of large and complex datasets (hig). In the context of this project, the generation of plots via HighCharts allowed for the simultaneous visualization of 6 different kiosk activities throughout a 24 hour period. The HighCharts interactive features enable the user to focus on a specific kiosk or collection of kiosks and permits zooming into particular time frames.

Results

Using the log file for May 24, 2017, the JavaScript code in HTML generated the plot shown in Fig.3. The plot shows the activity of all 6 kiosks at the Cedars Cancer Centre based on log file data. The following section focuses on each kiosk activity separately. The plot is manipulated using the interactive legend.

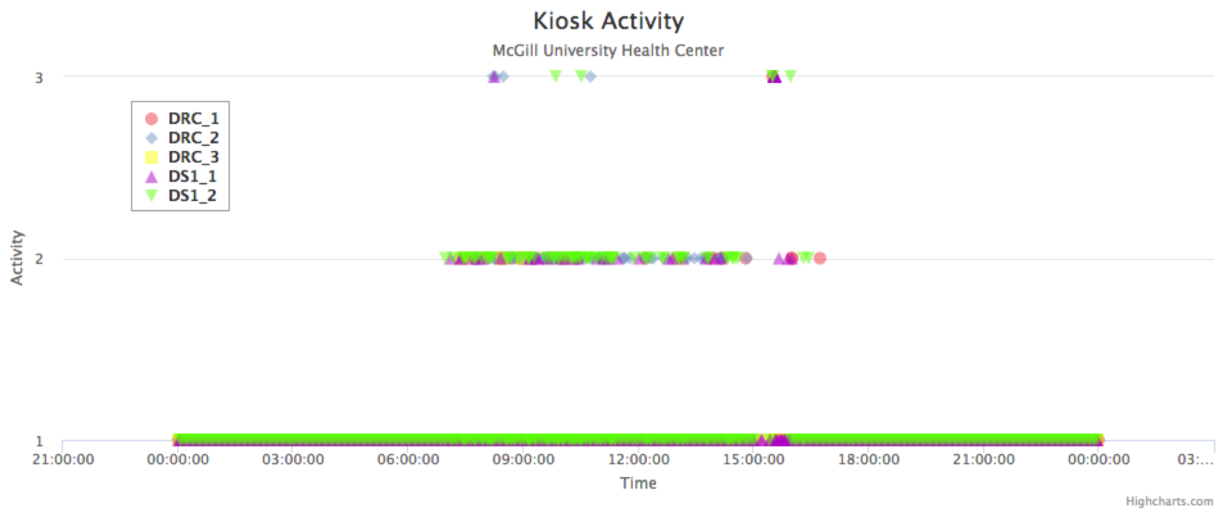

Figure 3: A Plot of Kiosk Activity Against Time at the Cedars Cancer Centre for May 24, 2017

DRC_1

A plot of kiosk activity that focuses solely on DRC_1 can be acquired using the interactive legend found in Fig.3. The DRC_1 kiosk activity is displayed in Fig.4. System downtime can be visualized more clearly by zooming into Fig.4. as indicated in Fig.5. In this example, the DRC_1 kiosk experiences a downtime of approximately 30 minutes, starting at 15:00:00. Apart from this instance, this kiosk maintains a regular heartbeat throughout the 24 hour period. The plot of kiosk activity for DRC_1 also shows a number of successful check-ins and single unsuccessful check-in. Ultimately, this kiosk experienced 31 check-in attempts on May 24, 2017.

DRC_2

The plot for DRC_2 kiosk activity is shown in Fig.6. This kiosk maintains a regular heartbeat until about 15:00:00. Subsequently, the kiosk experiences downtime for the rest of the day. The plot shows a number of successful and unsuccessful check-ins. Ultimately, this kiosk experienced 84 check-in attempts on May 24, 2017.

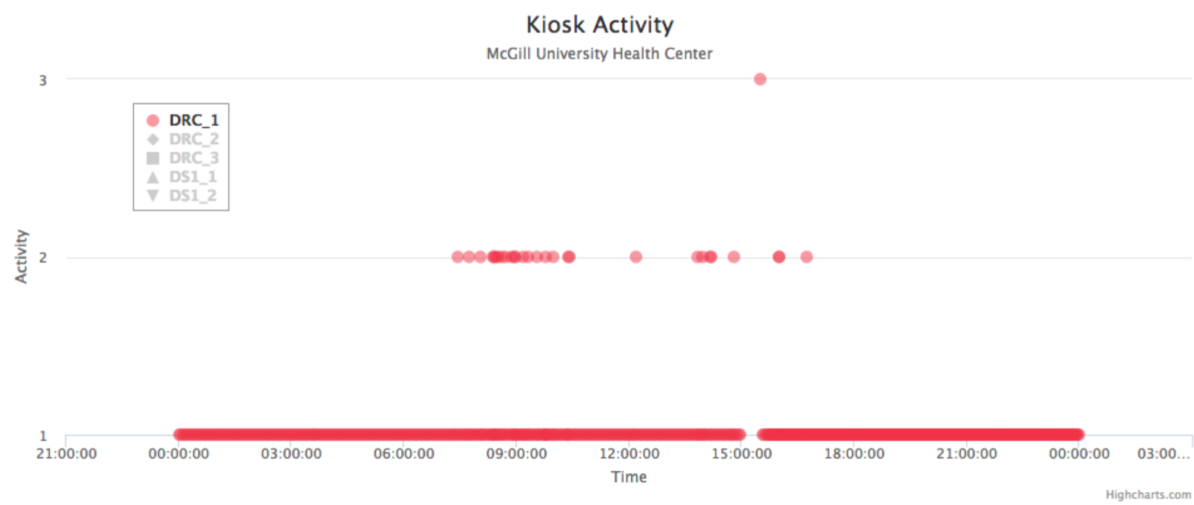

Figure 4: DRC_1 Activity for May 24, 2017

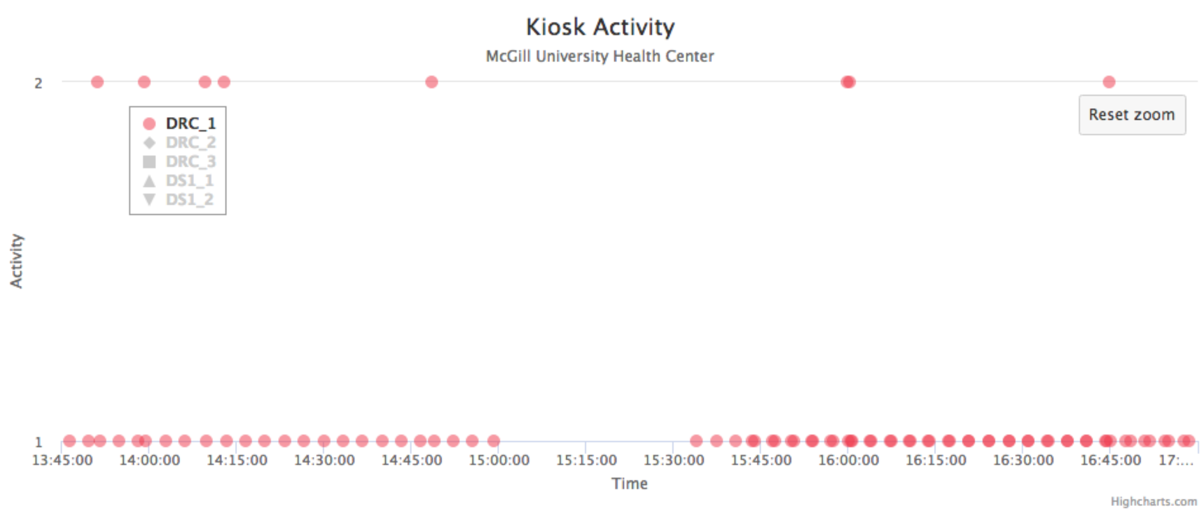

Figure 5: DRC_1 Downtime

DRC_3

DRC_3 kiosk activity is depicted in Fig.7. System downtime starting at approximately 15:00:00 is observed more distinctly in Fig.8. Otherwise, the kiosk maintains a regular heartbeat throughout the time frame. Successful check-ins are present in this plot, while no unsuccessful check-ins are observed. This kiosk experienced the least amount of check-in attempts on May 24, 2017. 6 attempts were recorded.

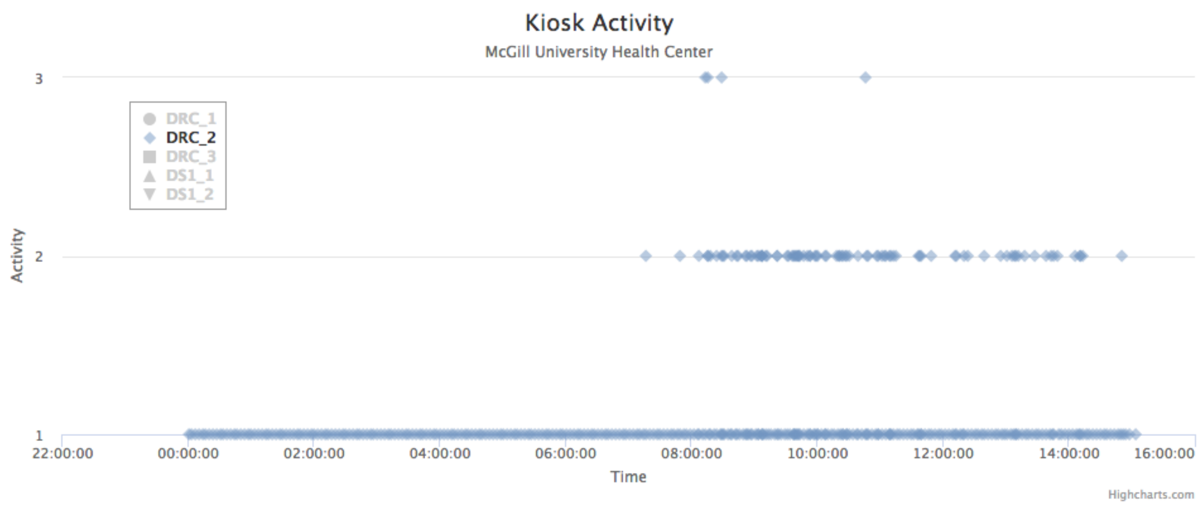

Figure 6: DRC_2 Activity for May 24, 2017

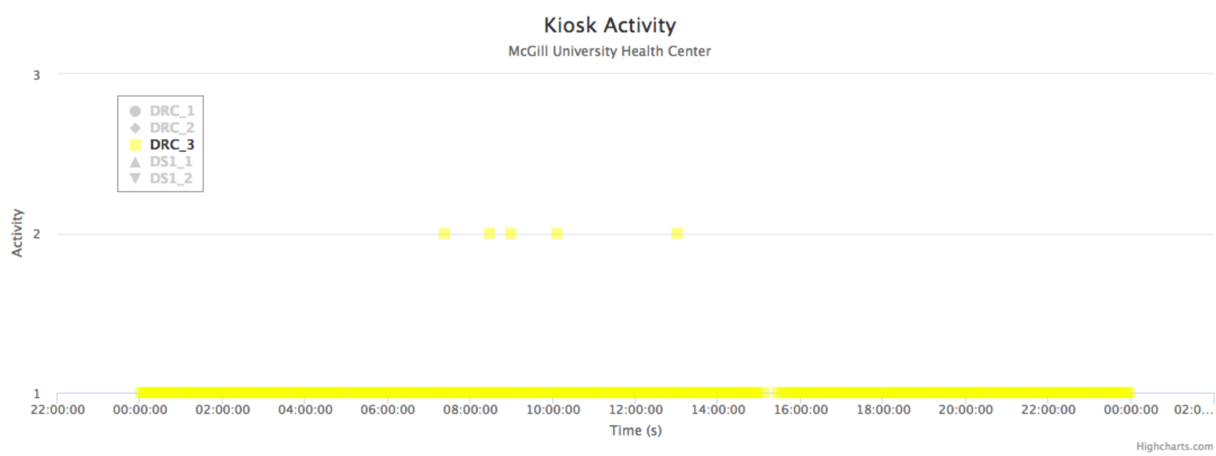

Figure 7: DRC_3 Activity for May 24, 2017

DS1_1

A plot of DS1_1 kiosk activity is found in Fig.9. As previously mentioned, DS1_1 represents 2 kiosks. Throughout the day, the kiosks maintained a regular heartbeat, with the exception of the time period between 15:00:00 until 15:30:00. The plot shows a number of successful and unsuccessful check-ins. Ultimately, these kiosks experienced a total of 37 check-in attempts on May 24, 2017.

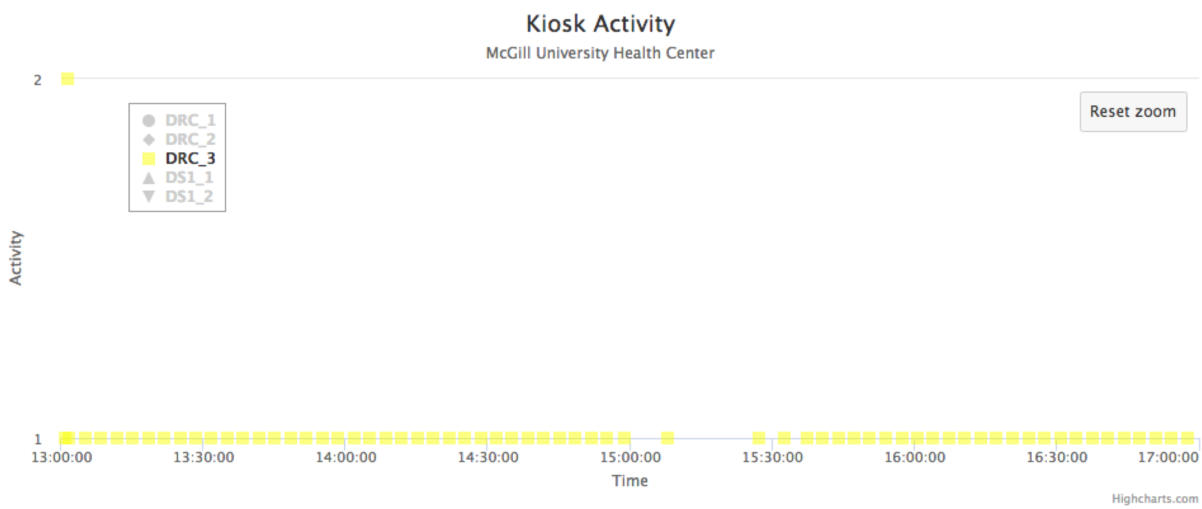

Figure 8: DRC_3 Downtime

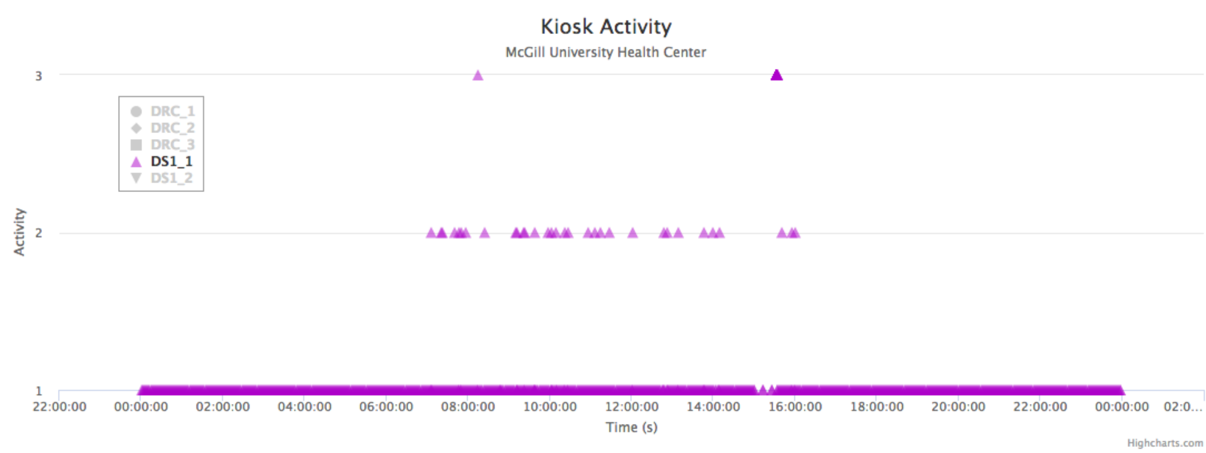

Figure 9: DS1_1 Activity for May 24, 2017

DS1_2

DS1_2 kiosk activity is shown in Fig.10. System downtime is noted between 15:00:00 until 15:30:00. The plot shows a number of successful and unsuccessful check-ins. This kiosk experienced the greatest amount of check-in attempts on May 24, 2017. 100 attempts were recorded. The number of check-in attempts for each kiosk is summarized in Table 2.

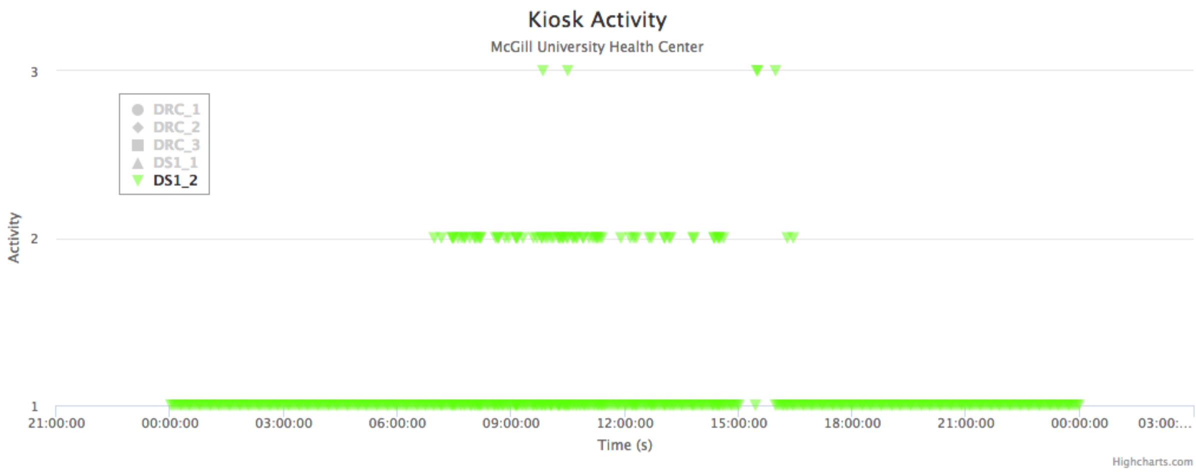

Figure 10: DS1_2 Activity for May 24, 2017

Kiosk ID	Number of Check-in Attempts
DRC_1	31
DRC_2	100
DRC_3	6
DS1_1	37
DS1_2	84

Table 2: Number of Check-in Attempts for May 24, 2017

Discussion

Kiosk heartbeats, successful check-ins and unsuccessful check-ins can be graphed against time to create informative plots regarding the activity of several kiosks. Using HighCharts, this activity can be assessed individually or simultaneously. Fundamentally, these plots clearly identify kiosk downtimes by looking at abnormalities in heartbeat intervals. Kiosk downtime periods are linked to database errors or other system failures in the ORMS. The ability to handle kiosk downtime in an efficient and timely manner, is important for the successful implementation of the ORMS at the Cedars Cancer Centre. In the future, a feature that sends automatic alerts to the hospital technical services team during potential downtime periods can be developed. This has the potential to minimized kiosk downtime as a result of real-time communication. Furthermore, previous kiosk activity can be used to determine normality within the system. Abnormality can also be detected by monitoring real-time activity within the system. Ultimately, retrospective data will provide information that is useful for a future research study into the system.

The plots generated through HighCharts also showed successful and unsuccessful kiosk check-ins. The number of check-ins for each kiosk can be calculated based off these plots as indicated in Table 2. Future research could look into optimizing kiosk locations, which is crucial in the successful implementation of kiosks (Rhoads and Drazen, 2009b).

Conclusion

A logging tool that visualizes kiosk activity can be used to identify kiosk downtime. In the future, this tool has the potential to minimize ORMS downtime, by providing real-time alerts to hospital technical service teams.

Appendix

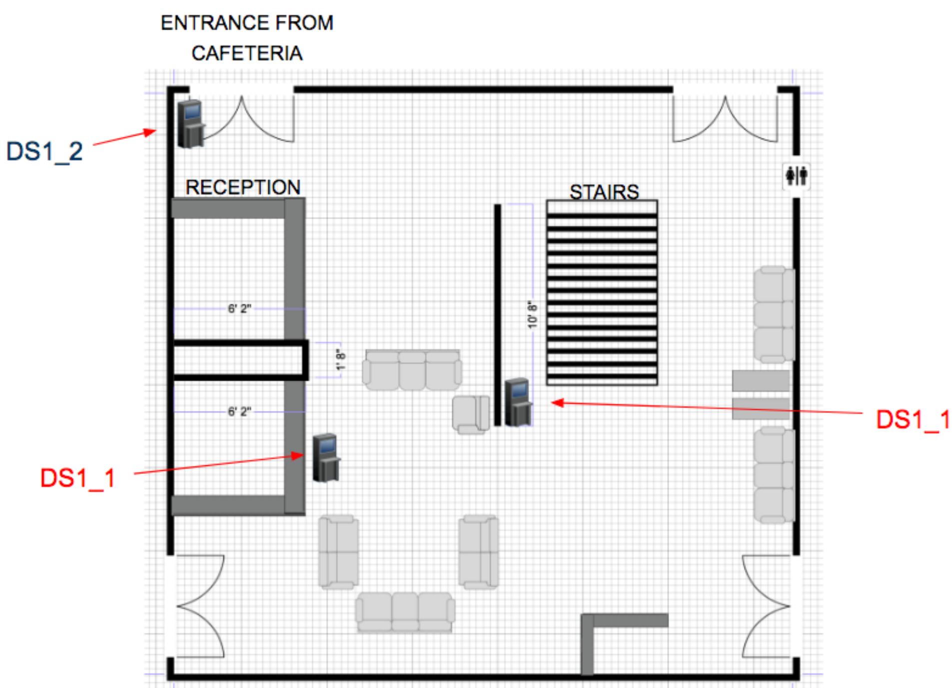

Figure 11: Kiosk Locations on Ground Floor at Cedars Cancer Centre

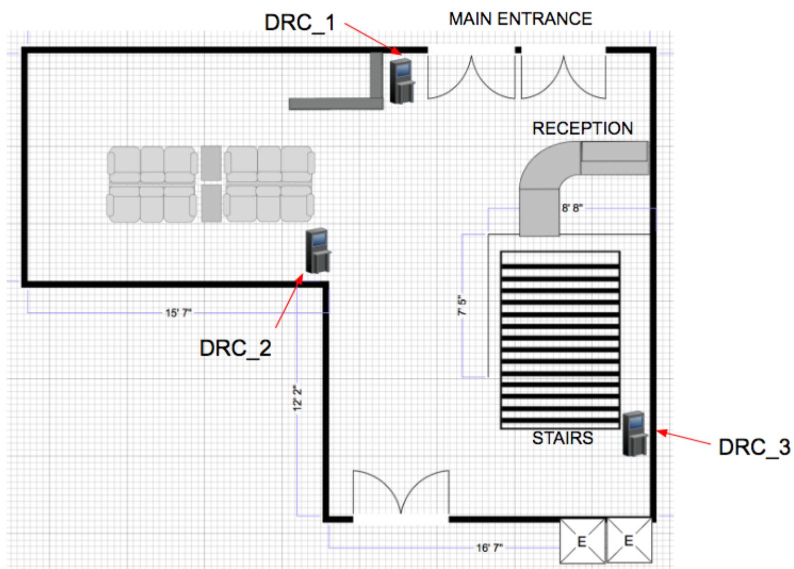

Figure 12: Kiosk Locations on First Floor at Cedars Cancer Centre

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